TeV Energy Superconducting Linear Accelerator

The TESLA Accelerator Module Test Facility

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Objectives of the Test Facility

The Tera-eV Energy Superconducting Linear Accelerator (TESLA) will consist of about 21000 superconducting RF 9-cell cavities of pure niobium, cooled in a 2.0 K helium bath. The cavities will be assembled in groups of 12 in about 16-17 m long cryostats (cryomodules). Among other things, the cryomodules will be equipped with thermal shields at 40-80 K and 5-8 K temperature levels respectively.

Before their installation in the TESLA tunnel, the about 1800 accelerator cryomodules have to be qualified. The qualification includes the check of the general mechanical dimensions and the measurement of the cryogenic performance of all systems, in particular, the performance of the cavities. At the start of the cryomodule series production the tests will cover 100 % of the cryomodules, in order to check and adjust the fabrication. As soon as the non-acceptance rate will decrease below a value in the order of 1 %, only about 25 % of the cryomodules will be tested.

For the time being, the performance of single superconducting RF-cavities can only be monitored by cryogenic tests. Industrial studies have shown that the effort, needed for the cryogenic tests of single cavities pays, as soon as the failure rate of the single cavities exceeds 1.2 %. Also the overall accelerating gradient of the linear accelerator can be improved in the range of more than 10% by sorting of the cavities according to their performance. For the fabrication of the TESLA cryomodules more than 21 000 single cavities have to be tested at a rate of about 24 cavities per day.

In addition, about 800 packages of superconducting magnets (quadrupoles and steering dipoles) have to be tested in vertical dewars at an average rate of one quadrupole per day.

In general, with the exception of the tests of prototypes, the tests will aim only at quality insurance. For the cavities as well as for the cryomodules the test results from the test facility will be used as a fast feedback into the series production in order to avoid failures and to increase the performance.

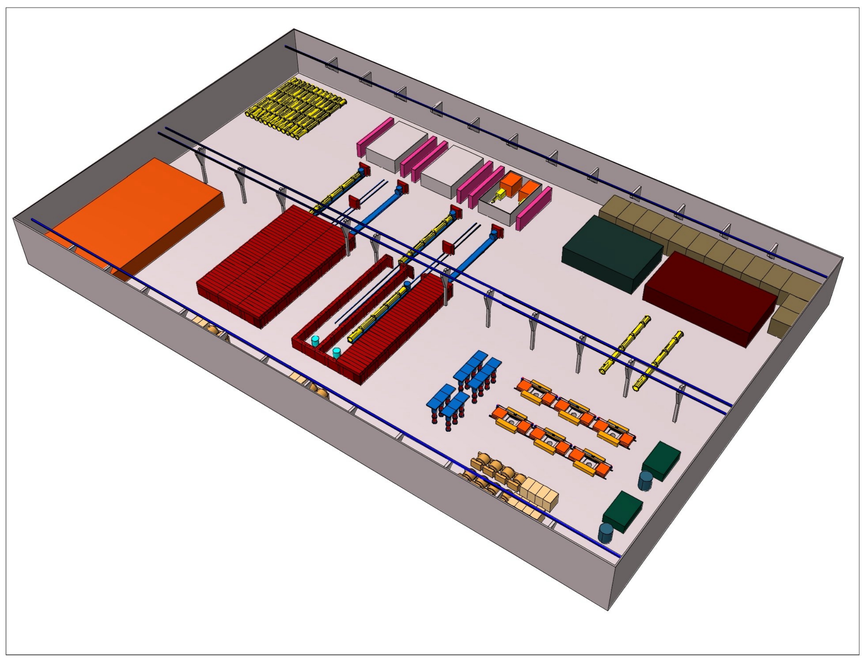


Figure 1: Artist's View of the Accelerator Module Test Facility

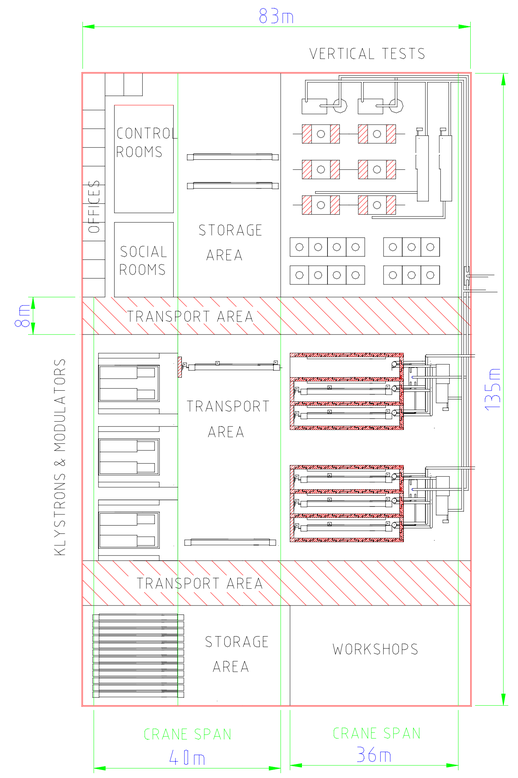


Figure 2: Ground Plan of the Accelerator Module Test Facility

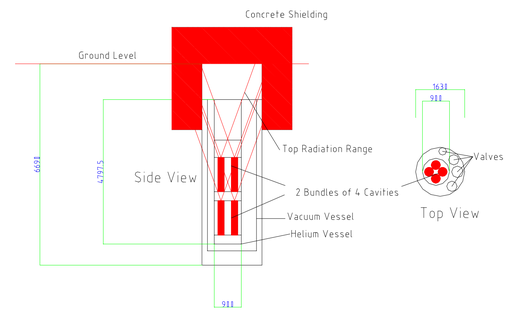


Figure 3: The overall size of one vertical test dewar containing 2 bundles of 4 cavities

Test Programme for the Accelerator Module Test Benches

Performance of about 1800 Accelerator Cryomodules
- General leak check of all vacuum systems and cryogenic process tubes
- Tests of the instrumentation
- Measurement of the static heat loads
- Measurement of the maximum accelerating field of the cavities
- Monitoring of the unloaded RF quality factor Q_0 by means of cryogenic heat loss measurements
- Monitoring of X-rays and dark currents

Methods:
- 6 test benches including the connections of all 40-80 K, 5-8 K and 2 K helium process circuits
- One 10 MW klystron & modulator for each test bench

The Cryogenic System

Cryogenic loads:
- 10 KW at 40-80 K
- 1 KW at 4.5 K
- 50 g/s helium liquefaction at 4.5 K
- 0.6 KW at 2 K (use of warm helium compressors)

Cryogenic equipment:
- Six Vertical Dewars (2.2 m^3)
- Two 10 m^3 liquid helium storage dewars
- Two distribution-boxes (for the vertical dewars)
- Six Accelerator Module Test Benches (each consisting of feed-box, feed-cap and end-cap)
- Two sub-cooler & valves-boxes (for the module test benches)
- One hall distribution-box
- Helium transfer lines
- Four sets of 300 K helium compressor units (5-10 g/s at 10 mbar, compression to 1.3 bar)

Cryogenic Plant:
- The cryogenic system of the test hall can be connected to the existing HERA cyrogenic plant or to one TESLA cryogenic plant on the DESY site

Test Programme for the Vertical Tests of Single Cavities and Magnet Packages

Performance of about 21 000 single superconducting RF cavities:
- Maximum accelerating field
- Unloaded RF quality factor Q_0

Methods:
- 8 cavities are assembled in one cryostat insert
- Measurements in a 2.2 m^3 liquid helium bath at 2 K
- Fixed coupler antenna and pick up probe

Performance of about 800 superconducting Magnet Packages (Quadrupoles & Steerer Magnets)
- Current performance

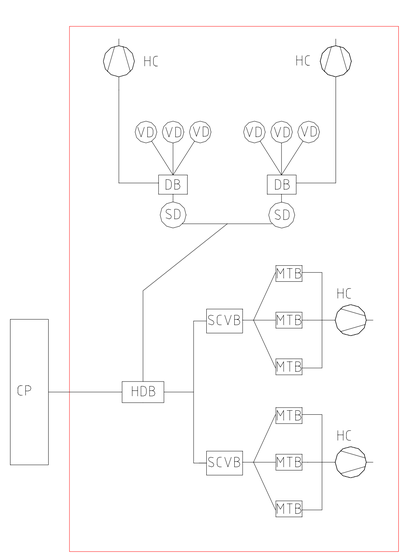
Methods:
- 2 magnet packages will be assembled and measured in one cryostat

Table 1 : Schedule for the test of 8 cavities in one vertical dewar
The indicated numbers correspond to the 4.5 K liquefaction load (g/s)

Time / h	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Assembly																				
Pump & Purge,leak checks																				
Cool down 300K->4.5 K																				
Cryostat filling							50	50												
pump down 4.5K->2K										20	20									
measurement 2 cavities												8								
measurement 2 cavities													8							
measurement 2 cavities														8						
measurement 2 cavities															8					
warm up 2k -> 300K																				
Dis-assembly																				

Table 2: Schedule for the test of one cryomodule containing a magnet package.
The indicated numbers correspond to estimated test hours.

days	1	2	3	4	5	6	7	8	9
Test Bench									
connections	24								
iso-vacuum		24	24						
tube leak checks				8					
beam-vacuum		24	24						
coupler pumping/heating		24	12						
coupler processing				24	24				
cavity processing							20		
cool down					24	24			
tuner tests						4			
dynamic losses							4		
static losses						24	4		
magnetl tests							4		
warm up								24	
disconnections									24



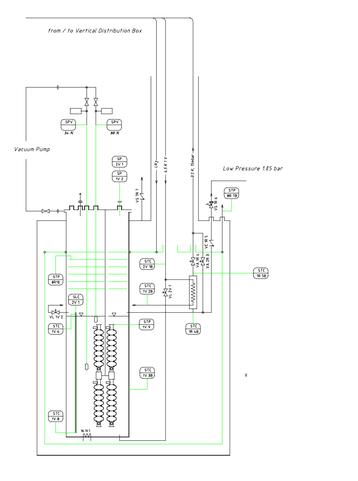


Figure 4 : Cryogenic flow scheme of one vertical dewar

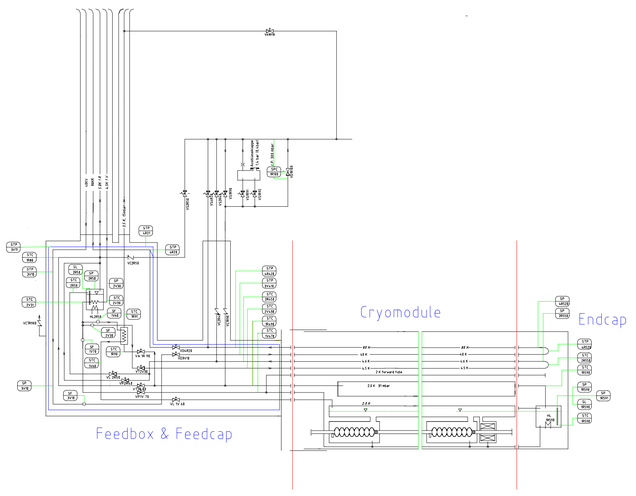


Figure 5: Cryogenic flow scheme of one module test bench

Figure 6.: Block Diagram of the Cryogenic System
CP= Cryogenic Plant (HERA or TESLA), HDB= Hall Distribution Box, SCVB= Sub-cooler & Valves Box, MTB= Module Test Bench, HC= Helium Compressor, SD= Storage Dewar, VD= Vertical Dewar